ATACAMA II: NOMAD ROVER SAMPLE 1-250697 AND IMPLICATIONS FOR FOSSIL CHARACTERIZATION DURING MARS EXPLORATION. Nathalie A. Cabrol[1], Guillermo Chong Diaz[2], George Dunfield[1], James Dohm[3], Mario Pereira Arredondo[2], Virginia Gulick[1,4], Arturo Jensen Iglesia[2], Rendy Keaten[5], Cristian Herrera Lamelli[2], Ragnhild Landheim[1,4], Pascal Lee[1], Liam Pedersen[6], Ted Roush[1], Kurt Schwehr[7], Carol Stoker[1], Aaron Zent[1]. [1] Nasa ARC, Space Science Division (CA), [2] Universidad Catolica del Norte (Chile), [3] USGS Flagstaff (AZ), [4] SETI Institute (CA), [5] USGS Menlo Park (CA), [6] FRC, Carnegie Mellon University, [7] IMG, NASA ARC (CA). Email: ncabrol@mail.arc.nasa.gov.

This abstract focuses on the encounter with an intriguing rock (hereafter designated sample 1-250697) made by the Nomad Science Team on Site 4 during the "Science on the Fly" operation, which raised numerous questions about rock sampling, fossil identification, and our readiness to recognize life. The strategy of the operation is summarized here to help understand the decisions made by the Science Team, their consequences, and the implications for planetary exploration that can be learned from them. The science on the fly strategy was tested for the first time during this field experiment in Chile. The requirements were that the rover was kept in motion for 75% of the time, and that the rest of the operation was devoted to science interpretation. The goals were: (a) to develop exploration strategies for long-traverse missions, (b) determine whether or not successful interpretation and global knowledge of a site, are related to the time spent on target. Except for a magnetometer and a meteorological package, the Nomad rover was carrying no science instruments but an imagery system, including human-eye resolution cameras, (described in *Atacama I*, this LPSC volume). Rover based characterization of the study area to Site 4 included stromatolitic structures suggesting near-shore algal mat environment. At Site 4, an image the stratigraphic section was taken using the panospheric camera. Several boulders and rocks were observed along the slope. Among them, one rock showed a dark feature on its upper side. A high-resolution stereo image was taken (figure 1). Compared to the surrounding rocks, the sample was noted to contain an *"anomalous clast...possible fossil"* by the ARC Science Team. Three hypotheses were proposed: (a) a possible fossil (ammonoid or algal mat structure), (b) a chert nodule, and (c) iron-rich conglomerate clasts. The fossil hypothesis was supported by the shape of the anomalous clast, and the remotely interpreted environment in the vicinity of Site 4. As the potential first fossil ever spotted by the eyes of a rover's cameras, the rock was sampled and numbered by the field team, who provided a temporary interpretation at the end of the operation: "*lacustrine limestone, conglomeratic…(in) proximity of an ancient coast-line. The fossil material corresponds to reworked fossiliferous material from Jurassic Age. It resembles corals, and algae-carpet material in places, with remains of shells. Most of these fossiliferous remains are associated to concretions*". Field hand-sample inspection of the sample confirmed the presence of chert. Fossil algae mat material was the interpretation made by the Field Science Team. The chertification process was so advanced that field observation could not verify the existence of any fossil remnants. The sample was shipped back to ARC for analysis. The ARC Science Team composed of geologists and biologists confirmed the advanced chertification of the sample, and agreed that thin sections were necessary to verify the existence of microfossils. Biologists reviewing the hand sample described the anomalous clast in the sample as being *"suspicious"*.

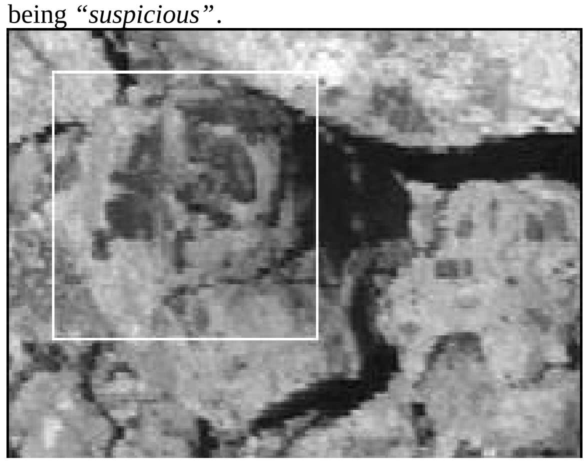

Figure 1: Box shows Sample 1-250697 in place in the field. The sample is approximatly18 cm high (plan view photo).

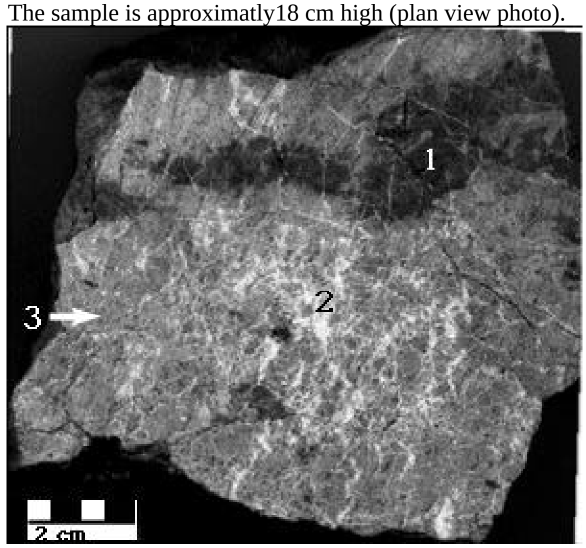

Figure 2: Longitudinal cut through the chertified dome structure. 1) chert through structure, 2) calcite cement and veins, 3) carbonaceous matrix.

The first section cut (figure 2) further supported the Field and ARC Science Teams earlier interpretations: the plan and longitudinal views of a dome through structure were consistent with the algae hypothesis. Thin sections of the chert and carbonate portions of the sample were then prepared (figures 3 and 4).

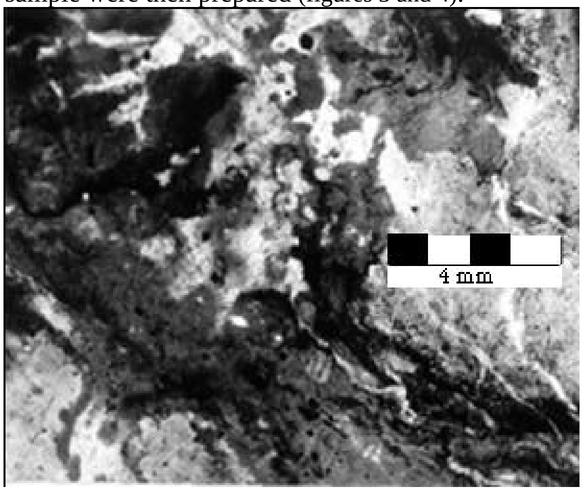

Figure 3: Thin section through chertified dome structure with no visible fossils or remnant structures.

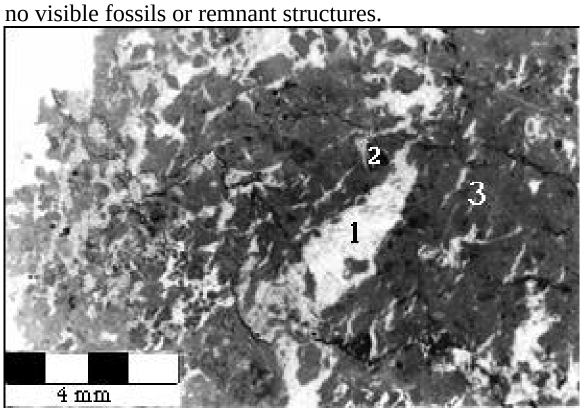

Figure 4: Thin section through carbonate matrix. 1) Crystalline carbonate cement, 2) mafic accessory minerals (primarily pyrite), and 3) carbonate matrix. Note: limonite alteration of mafic accessory mineral seen as opaque veins.

No evidence verifying the algal mat hypothesis was observed in any of the thin sections. However, it is possible that any biogenic structure that may have existed (strongly suggested by the environment of near-shore algal carpet of Site 4), may have been totally replaced without preserving any biogenic features. Unless we find conclusive evidence of fossil algal material within other thin sections, we could not confirm the possible biogenic origin of the structures observed in this terrestrial sample. For the coming Mars rover exploration missions focusing on the search for life, the fossil identification of sample 1-250697 suggests that even a comprehensive field and laboratory identification process can lead to inconclusive results. This has several critical implications for to the exobiologic investigation of Mars: (1) After the sample return, we can be holding remnants of Martian life in our hands and not have the tools to recognize it. A typical example is the Alan Hills meteorite ALH 84001, for which the current technology cannot confirm or rule out the hypothesis of nanobacteria. It can be argued that a sophisticated imagery system will be the most effective tool to identify life on Mars, which leads to the second implication of the Nomad field test. (2) Site 4 indicated that the imagery system was an important strategic and tactical tool, the utility of which can not be denied in a reconnaissance of surface fossil records. If Nomad had carried spectrometers, biological experiments, and to the extreme, a thin-section device, it is likely that the fossil identification results of sample 1-250697 would have been similarly inconclusive. In the context of Mars exploration with probably very similar environments (lake shoreline, altered iron-rich carbonate units), the primary tools for the rover reconnaissance and selection of potential study areas will remain the imagery system. Using only the imagery system, correct area characterization of the geology and stratigraphy led the Science Team to Site 4 and then to spot sample 1-250697 on the fossiliferous unit, thus breaking the barrier of misinterpretation of the previous rover field tests. Powerful rover-mounted cameras will be the tools that identify likely fossiliferous units and any "*suspicious rocks"* within them. This is relevant for the next rover mission that will carry the *Athena* science package. The experience of previous tests, where the camera resolution was inferior to Nomad's imagery system, showed that using less powerful resolution than Nomad's for Mars would result in diminished chances of success. (3) Finally, we would like to emphasize that flexibility in traverse science planning and ability to re-evaluate mission priorities are probably important keys for success. During the science on the fly operation, the Science Team was focused on keeping the rover moving, and obtaining the best geologic interpretation at the same time. Once the images of 1-250697 taken, the rover was sent to another target, leaving the Science Team with a cached "suspicious rock". In the interpreted near-shore environment, the discovery of possible fossil algal mat structure could have triggered a more comprehensive study of Site 4. Futher study of site 4 would have revealed non-ambiguous macrofossil evidence, i.e., *coquina*.

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